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SOCIAL SURVEY FINDINGS ON  
EN ROUTE NOISE ANNOYANCE ISSUES

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## Introduction

## Overview

Most surveys of residents' reactions to aircraft noise have been conducted in the vicinity of airports. The findings in those surveys have supported planning and regulatory actions for the airport noise environment. Now, however, aircraft noise planning and regulations are being considered for a new environment, the en route environment. As policy makers search for bases for public policy in these new noise environments, it is appropriate to ask whether the same scientific evidence which supports airport noise policy can also support en route noise policy. This paper considers several aspects of that question.

The paper is divided into four sections. An introduction establishes the scope of the present study and examines alternative study methodologies. Next, the selected study methodology is described and important assumptions are listed. The body of the paper then consists of the findings on en route issues. The final section presents findings on relevant research methods and considers priorities for further research.

### Introduction

### Final study methodology

### Findings about en route/airport differences -

### Methods and priorities for further research

## Introduction: En Route Aircraft Noise Surveys

What type of methodology should be selected to provide information about en route noise reactions? An obvious approach is to examine any previous surveys of reactions to en route aircraft noise. Ten en route noise surveys have been identified and are listed in Table 1. Eight surveys studied reactions to sonic booms, one studied low altitude military flights and one studied helicopter flights. Each of the surveys found some annoyance with en route noise. None of the surveys is very useful for isolating the effects of the en route setting because any en route effects are confounded with the effects of the unusual noise sources studied. The only possible exception, the British Helicopter survey, was designed to be compared to previous fixed wing aircraft surveys in the vicinity of airports. This survey could not precisely estimate the noise/annoyance relationship because of the small number of study areas (six) and large differences between the reactions of the study areas. The survey did not find a systematic difference between reactions in previous surveys and those in the six study areas.

<u>Survey</u>	<u>Noise source</u>
1961 St Louis Sonic Boom <sup>1</sup>	Sonic Boom
1964 Oklahoma City Sonic Boom <sup>2</sup>	
1967 SR-71 Supersonic Aircraft <sup>3</sup>	
1965 Regional French Sonic Boom <sup>4</sup>	
1970 French Sonic Boom <sup>5</sup>	
1971 French Concorde <sup>6</sup>	Low Altitude Military Helicopter
1969 Meppen Sonic Boom Field Experiment <sup>7</sup>	
1972 Burgsvik Sweden Sonic Boom <sup>8</sup>	
1986 Netherlands Low Altitude Military <sup>9</sup>	
1982 British Helicopter Disturbance <sup>10</sup>	

Table 1: Ten surveys of en route aircraft noise  
(N=18,380)

## Introduction

## Objectives and Approach

The examination of these en route surveys has helped to clarify the objectives for the present study. The objective for this study is to understand how noise annoyance is affected by differences between the en route and airport noise environments. Other studies, including laboratory studies, are needed to understand how noise annoyance is affected by differences in noise sources. Such studies compare the reactions to the noise of conventional aircraft and the noise from supersonic aircraft, propfan propulsion systems, low altitude military aircraft or any other noises which may dominate a specific en route noise environment. The objective of the present study is not to estimate a specific level of annoyance but rather to determine whether there is a difference in reactions between the en route and the airport environments.

The approach to this objective cannot be a simple comparison of existing en route and airport environment social surveys. The required approach is a more analytical approach in which the critical components of the en route environment are identified and expressed as hypotheses which can be individually tested under the range of conditions which are present in existing noise environments.

## Study Objective

Compare expected en route/airport noise reactions

Not Examine effect of specific noises

Not Estimate absolute levels or reactions

## Approach

Identify en route characteristics and test in existing environments

Not Contrast en route/airport surveys

Eight hypotheses have been identified which provide the bases for speculations that reactions to en route and airport noise environments will differ. These eight component hypotheses can be grouped under three headings.

Four hypotheses suggest that the presence or absence of an airport can effect reactions. Residents who are distant from an airport may be more annoyed because they would not directly benefit either through employment or usage from an airport's presence. It is hypothesized that annoyance is reduced if benefits are received from the noise source. The distant en route population could be expected to be more noise-sensitive generally, if the obvious presence of an airport has, over a period of time, served to create a self-selected population of airport residents who are relatively insensitive to noise. It is hypothesized that people at low noise levels are more sensitive to noise generally, regardless of the source. En route residents may also be differentially affected because aircraft are not engaged in conventional landing and take-off operations. It is hypothesized that annoyance is increased by exposure to non-noise problems from the noise source. It is also hypothesized that annoyance is increased if fear is associated with the noise source. The non-noise impact and fear hypotheses have different implications for low and high altitude aircraft. For high altitude aircraft, such as the propfan, en route residents may be less annoyed by the noise because they do not experience some of the non-noise problems associated with being near the source such as air pollution, dirt, lights or the visual presence of aircraft. They also may be less annoyed because they are less fearful of danger from an aircraft crash. For low altitude military training routes, on the other hand, en route residents may be more annoyed if they experience greater fear or other non-noise problems which could increase noise annoyance.

The en route noise environment differs in two additional respects. In contrast to the typical high ambient noise, urban setting around airports, there may be low ambient, rural or suburban settings at many en route noise locations. It is hypothesized that low ambient noise levels will heighten the reactions to any intruding noise. Much of the en route population could also be exposed to quite low aircraft noise levels; well below the typical 55 or 65 Ldn noise standards for aircraft noise which are often regarded as levels of minimum impact around airports.

Finally, some of the greatest attention is focused on a changing situation in which there is an introduction of a different or louder noise. It is hypothesized that there will be more annoyance with a changed noise environment than with a steady-state condition. It is also hypothesized that people adapt to new noise environments so that such a heightened reaction would be temporary.

## Hypotheses

Hypothesis	En route noise annoyance is		
	Less	Greater	Same
Airport /no airport			
Less benefit		H	
Non-noise problems*	H(HA)	H(LA)	
Fear /danger*	H(HA)	H(LA)	
Noise sensitivity (general)		H	
En route noise setting			
Low ambient noise		H	
Low (<55 Ldn) source noise*	H(HA)		
Change in noise			
Change in source noise		H	
Adaptation to change			H

\* (Opposite predictions for High (HA) and Low (LA) altitude en route noise)

How might these eight hypotheses best be examined? Three strategies were considered but rejected. Conducting a new social survey was rejected because more information is readily available from previous surveys than could be collected in one additional survey. A secondary analysis was considered in which the original, individual respondents' data in previous surveys would have been reanalyzed using a common methodology. A secondary analysis was rejected at this stage because all surveys, not just those with readily available data sets, need to be evaluated. A standard qualitative literature review was also considered but rejected. As has been observed for other areas of social science research..."Contemporary research reviewing should be more technical and statistical than it is narrative...The findings of multiple studies should be regarded as a complex data set, no more comprehensible without statistical analysis than would hundreds of data points in one study."<sup>11</sup>

The selected approach is to conduct a quantitative analysis of existing findings. Techniques for the statistical analysis of study findings have been developed under the general heading of "Meta-analysis".<sup>12,13,14</sup> The specific techniques can not be directly applied in summarizing results of environment noise surveys because these surveys do not use standard measurements of independent variables, do not use similar descriptive statistics and usually do not take into account the clustered sample designs in calculating inferential statistics. The meta-analysis literature does, however, set three general requirements which are applicable to the present analysis. A satisfactory quantitative analysis draws on an all-inclusive inventory of surveys, objectively documents the study methods and quantifies the findings with a suitable statistic.

New, single social survey

Secondary analysis

Qualitative literature review

Quantitative review of findings (Meta-analysis)

Requirements:

- Inclusive set of past studies
- Objective, documented methods
- Suitable summary statistic

The methodology which was finally adopted consists of fifteen steps. First, a major attempt to locate all English language publications describing surveys of residents' reactions to community noise identified 280 surveys of reactions to aircraft, road traffic, railway, industry, and other community noise. Next operational definitions of hypotheses were developed. Next, each of over 640 publications were evaluated to locate findings relating to the hypotheses.

After identifying a potential finding, a twelve-step screening and classification process classified the finding for the analysis. This methodology produced the types of records of findings which are shown in Table 2. Findings were screened out unless the annoyance variable measures the respondent's overall noise annoyance with a specified noise source within the context of the residential environment. The definition of the issue variable ("benefit" in Table 2) had to meet any special conditions related to testing the specified hypothesis. The reported number of respondents is approximate (sometimes only the sample size and not the exact number answering a question is available) and may be less than the total number of completed questionnaires when, as for a panel survey, there are multiple responses.

Once the relevant information was recorded, the finding could be coded by result for the study hypothesis (supporting the hypothesis, supporting an opposing hypothesis or not supporting any effect) and according to the strength of the supporting evidence (standard or weak). Supporting evidence was classified as "standard" if the design or data analysis method included a method for controlling or normalizing for differences in noise level and if one of three selected statistics had been used to measure the size of an effect. (An author's comments on unique survey attributes also occasionally caused a finding to be classified as weak.) It should be noted that the "standard" or "weak" classification considers only the relevance of the evidence for a specific hypothesis and is not a judgment of the overall quality of the survey.

- Identify social surveys (N=280)
- Prepare operational definition of hypotheses
- Examine all documents (N~640)
- Classify findings (12 steps)
  - Establish eligibility (annoyance/variable)
  - Determine results (Support/Against/No)
  - Evaluate support (Standard/Weak)
    - Summary statistic
      - Standard statistic (3dB, 5%, 1%r )
      - Other indicator
    - Control/normalize for noise
    - Other (issue-specific)
  - Determine sample size (Accuracy surrogate)



Issue: Benefits (employment, usage)

*Hypothesis: Annoyance is reduced by benefits received from the airport or other noise source.*

Study (Catalog ID number)	Finding: If benefit, noise annoyance is:			Methodology		Comments	Reference
	Lower	Same	Higher	Type of benefit	Variables controlled		
1975 German General Aviation (GER-114)	X <sub>r</sub> ns {1}			Involved profession- nally with air- field or aircraft	None	r <sub>ax</sub> = -0.03 [N=398]	Rohrmann, 1975:64
1972 English Road Traffic (UKD-072)	X <sub>s</sub> {1}			Car ownership, holding driving licence	Traffic flow (Vehicles per hour)	Only 3% fewer car owners scored high on disturbance. Disturb- ance is not related to number of vehicles. [N≈5,800]	Morton- Williams, Hedges, Fernando, 1978: 68, 72,88
1980 John Wayne Airport (USA-207)	X <sub>v</sub> {4}			Use of airport, weekly, monthly, yearly, other	Noise (All are in 65 CNEL contour)	Users"...are less likely to state that...aircraft noise is a problem for you in your neighbor- hood..." [N≈300]	VTN Consol- idated: X- 30
1982 United Kingdom Aircraft Noise Index (UKD-242)	X <sub>s</sub> ?s {1}			Work at airport or for compa- ny doing business with an airport	Noise (24hr L <sub>eq</sub> , for 1 week)	It is reported that "in some areas" economic ties are associated with a 25% decrease in rating of "not acceptable" (not individual-level analysis). [N≈2090]	Brooker and Richmond, 1985b:335; Brooker, Critchley, Monkman, Richmond, 1985:4,28, 59,131
1983 Controlled Exposure Helicopter (USA-235)	X <sub>dB</sub> ns {1}			Household member employed by military	Noise (L <sub>eq</sub> )	A not significant -0.3 dB response reduction for military. [n≈4000 daily interviews by N≈330 respondents]	Fields, Powell, 1987:488; Fields, Powell, 1985,41

Table 2: Example of a findings table (first five findings on benefits hypothesis)

The most critical aspect of the study methodology is the determination of whether a finding supports or does not support a hypothesis.

Each finding is classified by whether or not there is evidence of an "important" effect on annoyance where "important" is defined by specific statistical criteria. All statistics do not provide equally relevant evidence and thus a finding is classified by the highest level of evidence available. Six levels of evidence have been identified. One of the first three types of statistics must be available for a finding to be judged as "standard". The highest level of evidence comes from a measure of the decibel equivalent of the annoyance differential produced by a variable. The "important" effect criteria is an effect equivalent to the effect of at least a 3 decibel difference in noise level. A 3 dB equivalent effect favoring a hypothesis is counted as "support" for a hypothesis, a 3 dB effect opposing the hypothesis is counted as supporting the opposite of the hypothesis, and any effect of less than 3 dB is counted as not "important". If information about the decibel equivalent of an effect is not available, then statistics on the percentage differences between subgroups are sought. A 5% difference is defined as an "important" difference. For example, if residents living at an aircraft  $L_{dn}$  of 70 are examined and it is found that 25% of those employed by the airport are highly annoyed by aircraft noise but 35% of the remaining population are annoyed, then there is a 10% difference, and it is concluded that the finding should be counted as "important" support for the hypothesis. If evidence on the size of a percentage difference is not available then evidence about the percentage of variance explained is considered. An "important" difference explains at least 1% ( $r \geq 0.10$ ) of the variance. The choices of the 3 dB, 5% and 1% variance criteria are largely arbitrary. Most noise regulations use five-decibel step increments and thus it could be argued that a difference of less than three decibels would be unimportant. The 5% difference is approximately the increase in the percentage "highly" annoyed at about 65  $L_{dn}$  specified by one widely accepted dose-response relationship.<sup>15</sup> The 1% variance explained ( $r=0.10$ ) in individual annoyance scores is a largely arbitrary choice but is very approximately consistent with the other indicators in a few surveys in which it has been examined. For multi-category variables with uneven population distributions there is not a simple invariant relationship between the percent of variance explained and the other criteria.

Weaker evidence on a hypothesis can be provided by the results of a statistical significance test or (if no test is available) other numerical evidence (eg. differences between mean annoyance scores) or (if no other evidence is available) a verbal statement in a publication. Previous studies on meta-analysis methods have firmly established the fact that simple counts of the results of significance tests are very weak evidence and can bias the results of a summary.<sup>16</sup>

After all of the findings on a hypothesis have been classified, a final criterion must be applied to determine whether the combined results support or reject a hypothesis. In this paper a hypothesis is considered to be supported if over 50% of the tabulated findings show an "important" level of support for the hypothesis.

These simple criteria for evaluating hypotheses have the advantages of being unbiased, relatively easy to apply and readily transparent to readers. More powerful statistical methods are available for combining results from studies, but they require assumptions which could be legitimately met for only a small number of noise surveys. The broad scope of this less powerful review serves to identify major findings and, when the complete review is published, will provide a comprehensive listing of sources of information about major noise annoyance hypotheses.

## Methodology: Suitable Summary Statistic

Count findings showing "important" impact

Standard evidence

- $\geq$  3dB equivalent response difference
- $\geq$  5% difference in % annoyed
- $\geq$  1% variance explained

Weak evidence

- Significance test (only)
- Other quantitative
- Verbal statement (unequivocal)

Criterion to accept hypothesis

50%+ of findings support

## Results\*

### Benefits and Non-noise Disadvantages

This study's methodology has been applied to twenty-eight hypotheses about community noise annoyance. Fifteen provided evidence about the en route noise issues, three addressed social survey methods, three addressed additional demographic characteristics and five addressed individual noise exposure hypotheses. Of the 280 surveys examined, 120 surveys provided approximately 400 findings on at least one of the 28 hypotheses.

The first results in Figure 1 address the hypothesis that annoyance is reduced when a resident receives direct benefits from a noise source. The 22% for the first bar shows that of the 18 findings ( $F=18$  findings) which provide evidence on the hypothesis, only 4 ( $18 \times 0.22 = 4$ ) indicate there is an "important" effect supporting the hypothesis and none provide "important" support for the opposite hypothesis (i.e. that those receiving direct benefits would be more annoyed). Thus 78% of the findings do not provide evidence of an "important" effect. The first bar (solid bar) simply represents a count of all findings but does not consider the differing sample sizes or the relative quality of the findings.

The second bar adjusts for sample sizes and shows that the previously reported 22% of the findings represented 17% of the tabulated interviews. For the "benefit" hypothesis the interviews come from an estimated  $N=28,453$  respondents. The third and fourth bars (left and right diagonal fill patterns) represent only the "standard-evidence" findings. For the benefits hypothesis, for example, only 9 ( $F=9$ ) of the previously cited 18 findings are based on "standard" evidence. These 9 findings are based on only 12,503 of the 28,453 respondents.

For the benefits hypothesis all four of these summary statistics support a single conclusion: receiving a benefit from the noise source does not reduce annoyance. The best present evidence is thus that a lack of benefits does not affect en route annoyance.

For the second hypothesis addressed in Figure 1, non-noise problem, the evidence comes from five findings drawn from two aircraft surveys<sup>17,18</sup> and one railway survey<sup>19</sup> with 4,500 respondents (the "(3)" following the number of findings indicates that 3 surveys provided the five findings). Non-noise presence is measured by either the respondent's position relative to the flight path or by an independent observer's rating of the visibility of the railway and of the presence in the neighborhood of fumes, dirt or vibration from the railway. Only two findings (3060 respondents) met the standard evidence criteria. The finding from the smaller study supports the hypothesis. Using our 50% criteria (i.e. the shaded area in the figure), the four bars provide some mixed support for the hypothesis that noise reactions are affected by non-noise intrusions from the noise source. The results thus suggest that reactions to high altitude en route aircraft might thus be reduced while reactions to low altitude aircraft might be increased.

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\*This section contains figures 1-8.

## Findings about benefits and disadvantages from noise source

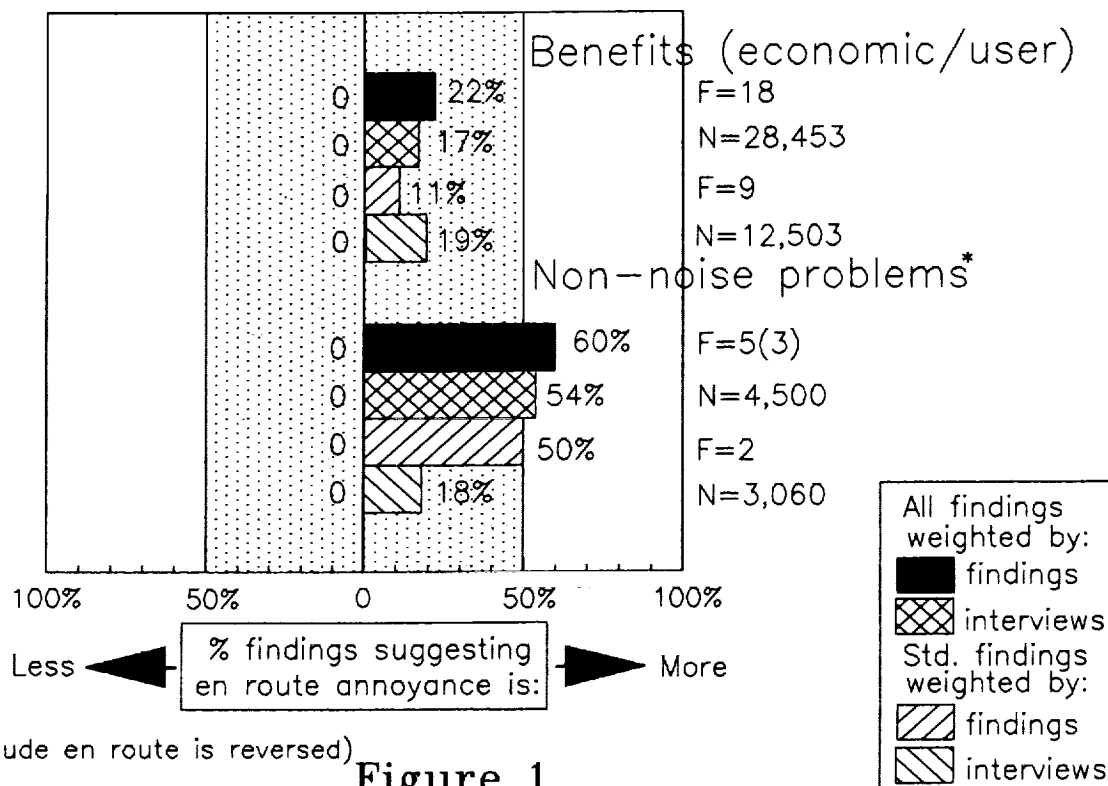


Figure 1

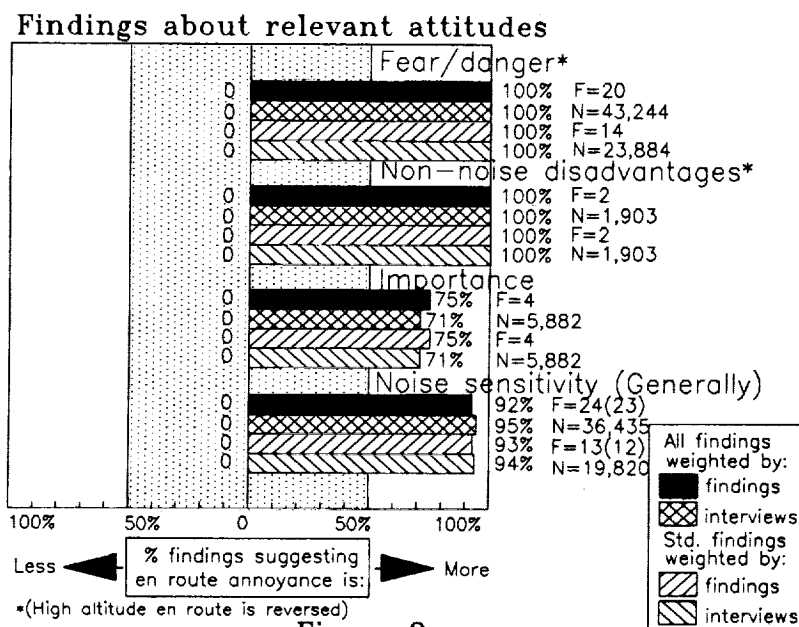
## Results

## Attitudes

Attitudes about non-noise disadvantages of the noise source were examined in two of the previous surveys using respondents' perceptions of aircraft air pollution or, in a railway survey, of railway dirt, smells, lights or invasion of privacy. The results in Figure 2 show that in both surveys respondents' perceptions of non-noise disadvantages are related to increased annoyance. This is thus additional, though weak, attitudinal evidence that annoyance may be increased by non-noise disadvantages.

The effect of fear or danger from the noise source (primarily from crashes for aircraft) has been examined in 20 surveys with 43,244 respondents. Every finding tabulated in Figure 2 shows that increased fear is associated with increased annoyance.

Three of four findings (5,882 respondents) support the hypothesis that noise annoyance is related to perceived importance of the local airport. Presumably attitudes towards any particular en route noise would be related to attitudes about the importance of the particular noise source. It could be speculated that, for example, annoyance with low-flying military aircraft would be reduced for those who believe such flights are important for national defense. While the data can show what variables are associated, any conclusions about the causal implications of such associations are speculative at best. For example, though the attitudinal data in Figure 2 suggest that people who feel the noise source is important will be more annoyed, the factual data on benefits in Figure 1 showed that those people for whom the noise source might actually produce important tangible benefits are not more annoyed.



## Results

## Sensitivity

The data on the last of the four attitudinal issues show that noise annoyance with aircraft is related to general noise sensitivity. Most questionnaires measure noise sensitivity by asking for the respondents' judgments about their own noise sensitivity relative to "most people" or by asking for ratings of annoyance from such common sounds as a banging door, dripping tap, or lawn mower. (For this report's hypothesis some surveys' measures of sensitivity have been excluded because they included references to local environmental noise.) For en route noise evaluation the critical question is whether such general sensitivity is related to the environmental noise level because more sensitive people might avoid high noise areas either by finally moving away or by initially not moving into the high noise airport areas.

In Figure 3 the data from 17 findings (over 30,000 respondents) indicate that there are not consistent, important differences in sensitivity between residents in high and low noise areas. The data from four findings indicate that residents are no more likely to move (or plan to move) from high than from low noise neighborhoods. One attitudinal variable is also reported in Figure 3. It is found that less than half of the five surveys (but representing more than half of the respondents) reported that respondents who are most bothered by the noise are also most likely to report that they plan to move. With such an attitudinal variable it is not clear, however, whether greater annoyance is causing the movement or whether the prospect of moving leads the respondent to a more negative evaluation of all aspects of the neighborhood environment. In either case the evidence for an effect is weak.

The evidence in Figure 3 does not support the hypothesis that general noise sensitivity is related to noise level. Thus the evidence does not suggest that traditionally low noise level areas will contain unusually noise-sensitive populations.

Findings about general noise sensitivity  
at high noise levels

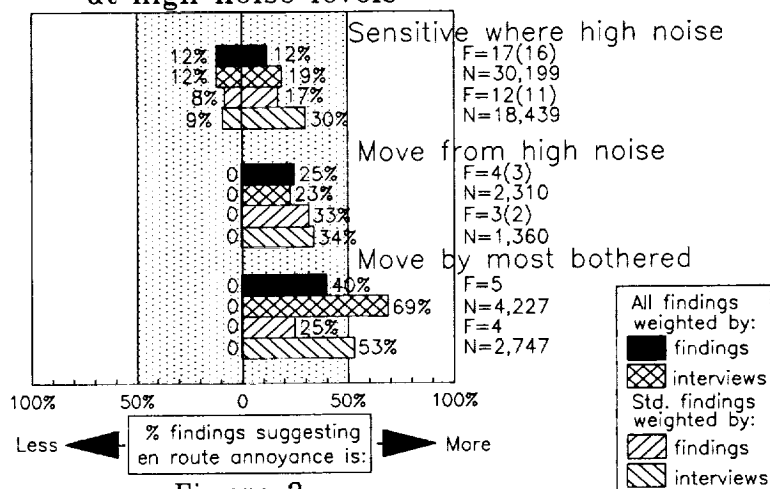


Figure 3

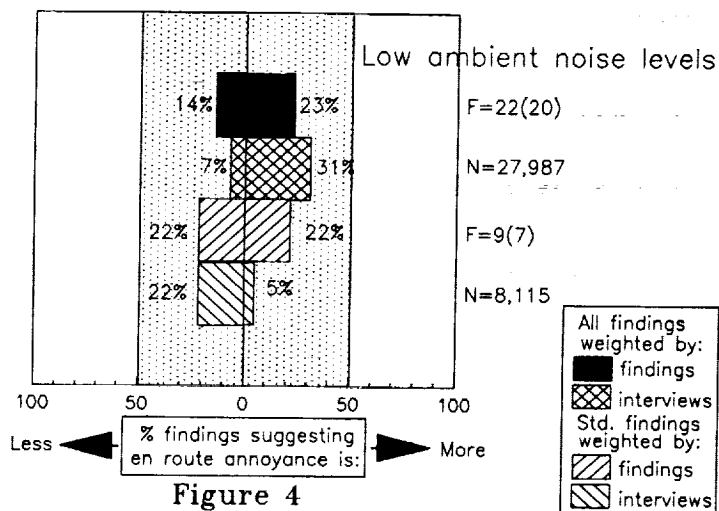
## Finding

## Ambient Noise

It is sometimes assumed that people will be more annoyed if a noise is experienced in the context of a low ambient noise environment. Figure 4 shows that 22 findings from 20 surveys (27,987 respondents) have evaluated the effect of ambient noise level on reactions to noise. Most surveys measured both the rated noise and ambient noise outside the house. The reaction is, as for all other findings, a rating of annoyance with a specific noise source. The data do not support the hypothesis that reactions to noise are affected by ambient noise level.

The survey reports do not directly measure the likelihood of masking of different noise sources. At least some of the surveys include sites with ambient noise levels below 40  $L_{eq}$  and some sites at which the rated noise source is sometimes masked by the ambient noise but sometimes clearly audible. Most of the data, however, probably come from sites where the rated noise source is seldom masked by ambient noise levels outside the home.

Findings about reactions at  
low ambient noise levels

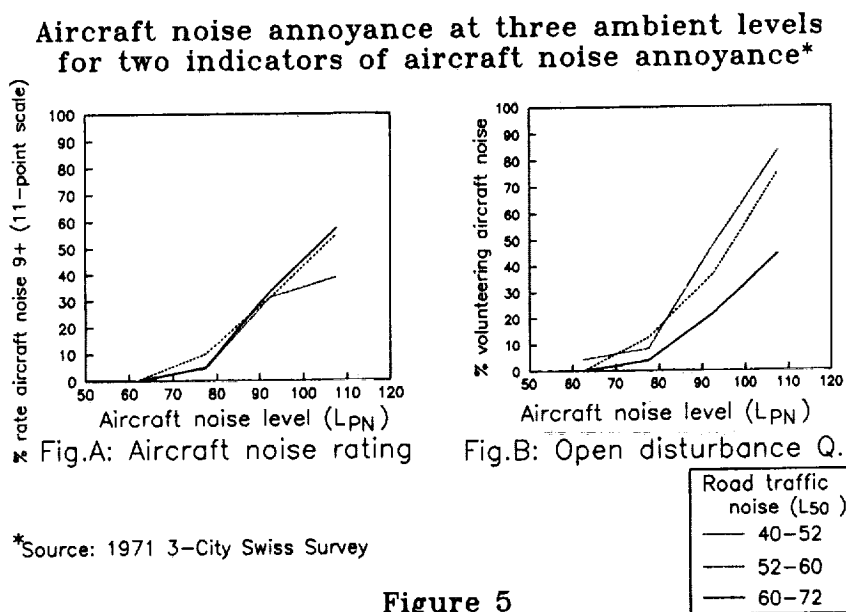




## Finding

## Ambient Noise

Some of the previously published support for an ambient noise hypothesis was examined. In some cases the conclusions are not based on direct ratings of a noise but only on relative rankings of ambient noises and other noise sources. The original report on the well-known 1971 Three City Swiss Noise Survey was examined for this review and it was found that ambient noise added less than one tenth of one percentage point (0.03%) to the explained variance. Figure 5A shows that the ambient noise level did not affect aircraft noise annoyance when measured on an 11-point "thermometer scale". (Aircraft noise level is the logarithmic average peak noise level for aircraft noise events expressed in PNDB.) In a 1978 review Schultz, however, cited the clear relationship with ambient noise in Figure 5B as evidence for an ambient noise effect.<sup>20</sup> This finding in Figure 5B is based on an open question which asked the respondent to volunteer anything in the nearby environment which the respondent disliked. Respondents seldom volunteer more than one or two answers to such a question and thus the question measures the relative salience of aircraft noise rather than the degree of annoyance with aircraft noise. These analyses and those from other surveys<sup>21</sup> show that people's absolute level of annoyance with a noise source is not affected by ambient noise but that the relative ranking of the importance or salience of several noise sources is, of course, affected by the relative noise levels of the sources.



**Figure 5**

## Results

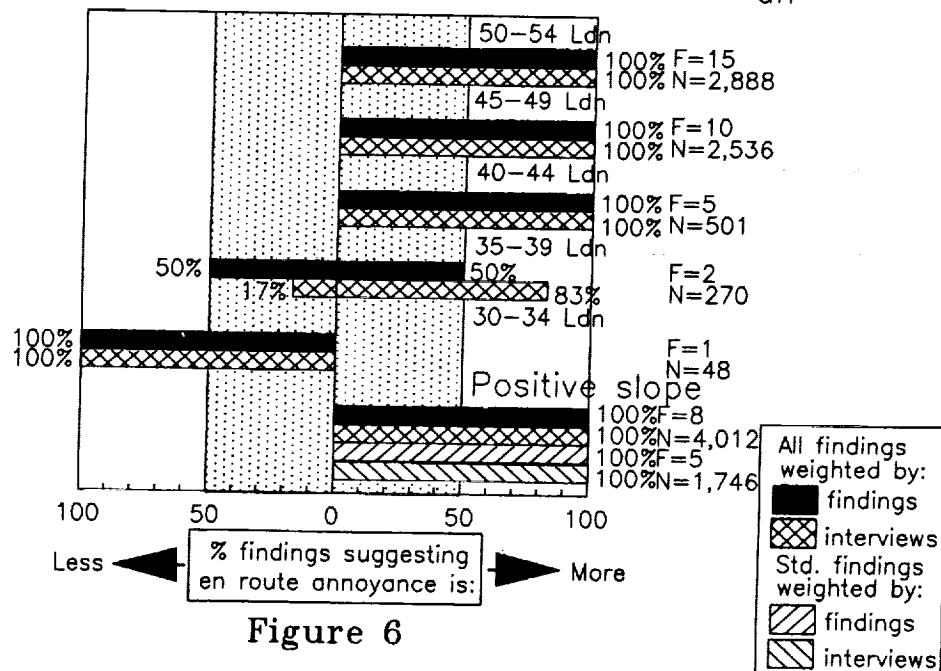
### Annoyance at Low Noise Levels

Most of the noise survey evidence comes from residents at high noise levels. Of the 280 surveys only 16 asked about high annoyance and included respondents at estimated noise levels of 55  $L_{dn}$  or lower. These surveys' findings are tabulated in Figure 6 for 5-decibel groups from 30 to 55  $L_{dn}$ . The first three pairs of bars in Figure 6 show that every one of the surveys which had interviews at the 50-55, 45-49 and 40-44  $L_{dn}$  levels found that some respondents reported high annoyance. Only two surveys provide evidence between 39 and 39  $L_{dn}$ . The 1971 Three City Swiss Noise Survey reported some high annoyance while the British railway survey reported no high annoyance.

Kryter has speculated from extrapolations of survey data that about four to eight percent of the population below 55  $L_{dn}$  may be supersensitive and thus be annoyed regardless of noise level. On this basis it could be argued that at low noise levels the response curve is asymptotic and that further reductions in noise level do not yield further benefits in reduced annoyance. This argument was tested with eight surveys which included data from 55  $L_{dn}$  down to 45  $L_{dn}$  or lower. As the data at the bottom of the figure show, in every case a positive slope relates annoyance to noise level.

The data reviewed in Figure 6 show that there is annoyance for noise sources with day/night levels of less than 55  $L_{dn}$  and that reductions of noise levels below 55  $L_{dn}$  yield benefits in reduced annoyance.

Findings about high annoyance below 55  $L_{dn}$



## Results

### Reaction to Change in Noise Level

The first two issues considered in Figure 7 contrast residents whose noise environment has recently changed to a new noise level with residents at the same noise level in other locations whose noise environment is unchanged. An "important" finding is recorded if those in the new noise environment over-reacted by the equivalent of at least 5 decibels compared to those living in the unchanged noise environment. The first 19 findings include both increases in noise levels and decreases in noise levels. The 9 of these 19 findings which come from increases in noise levels are reported separately in the second set of bars. There is not a clear pattern in the findings.

The remaining two issues in Figure 7 address the possibility that people may adapt to new noise environments over time. Seven surveys contrast reactions at two points after an increase in noise has occurred in order to determine if residents adapted. The number of respondents is relatively small and the evidence is again mixed. Though the number of surveys is almost evenly split between those showing adaptation over time and increased annoyance over time, the larger surveys (representing 49% of the respondents) are slightly more likely to show adaptation. The effect of length of residence in relatively stable noise environments is examined with 44 surveys. The evidence does not suggest that people adapt to noise over the time periods studied here.

Most of these surveys first measured respondents' reactions four months to a year after a change in noise environments. The lack of consistent support for the effect of change is thus consistent with the possibility of rapid adaptation in the first days or weeks of exposure.

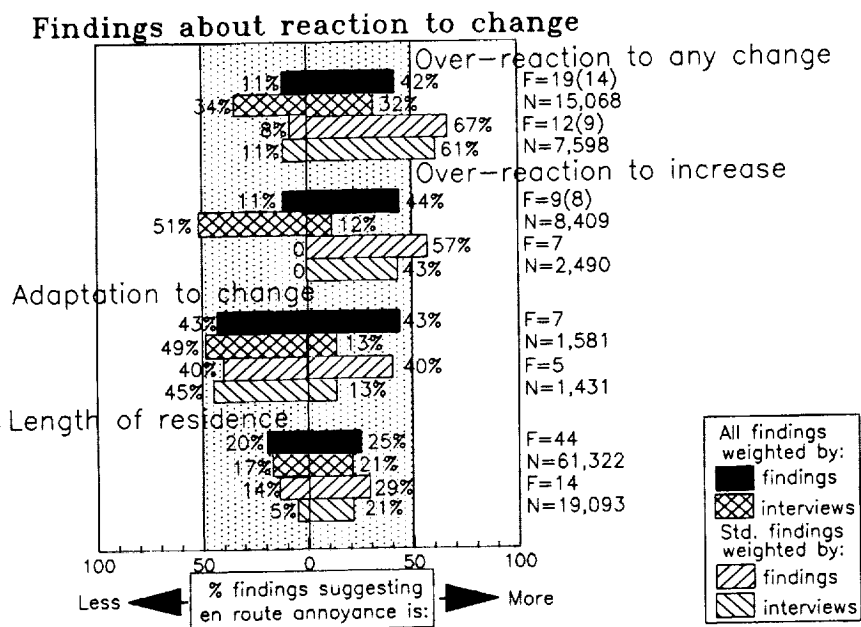


Figure 7

## Results

## Summary

The results of this study are summarized by returning to the eight original hypotheses. Two reasons remain for believing that some en route noise (only high altitude en route noise) might be less annoying than airport noise of the same noise level: the presumed absence of fear in a high altitude en route setting and the expected absence of any noise-source-related, non-noise problems in a high altitude en route setting. The evidence suggests neither general noise sensitivity, nor an absence of direct benefits, nor reduced ambient noise levels will affect reactions to en route noise. The evidence on changes in noise levels is unclear. The evidence on reactions at low noise levels shows that these surveys found high annoyance in areas which are estimated to have noise levels below 55 Ldn.

The methodology reported in this paper has provided an objective and concise review of the evidence on the presence or absence of eight variables' effects on noise annoyance. Further research would be needed to more precisely specify the size of any effects. Two types of methodologies could contribute to further research on these issues: new social surveys of annoyance in community settings and secondary analyses of the primary data sets of previous surveys. Cost is a primary consideration in conducting new surveys. Findings relating to cost-cutting methodologies and to required sample sizes have been examined.

Most previous social surveys of noise annoyance have been conducted with personal, face-to-face interviews, but many survey organizations now rely primarily on less expensive telephone interviews. Figure 8 indicates that four surveys have compared telephone and face-to-face interviewing methods. Only one met the standard evidence criterion, but none of the findings indicated that there was a difference between annoyance levels for telephone and personal interviews.

Probability sampling methods require that the respondent be selected using strictly controlled random selection methods from a list of all household members. Cost savings could be achieved, however, if an interview could be completed with the first individual contacted in a household. This procedure would bias a sample toward people who are often at home and thus are more exposed to the noise. Figure 8 indicates that there is not a clear tendency in the 17 identified surveys for the more often at home respondents to be more annoyed. Two of the four surveys with standard findings did find that those who are home more were less likely to be annoyed. In the 1960's and 1970's when many of these surveys were conducted, women were more likely to be at home. The findings from the 46 surveys in the figure indicate, however, that women are not more annoyed than men. According to the standard 50% criteria, the balance of the evidence suggests that the amount of time at home does not affect reactions. However, the evidence is somewhat mixed. Given the strictness of the probability sampling rules, these are probably not strong enough evidence to abandon the strict standard selection methods for choosing household members. It is possible that a secondary analysis of existing data might provide stronger evidence.

### Findings about cost-cutting methodology

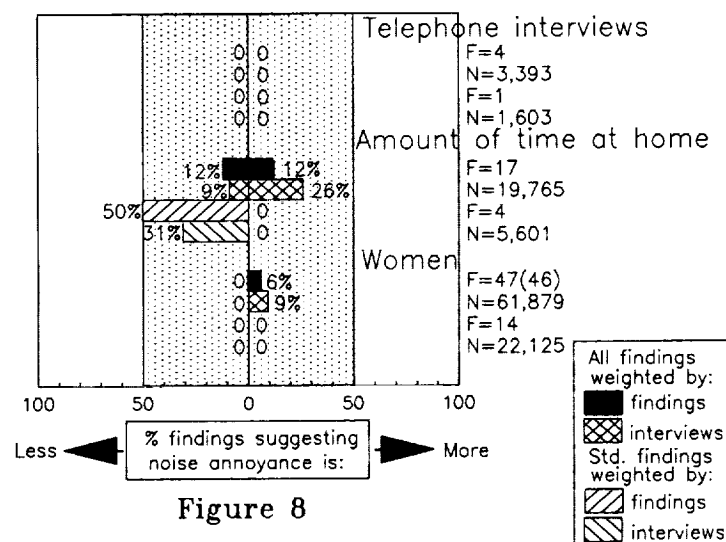


Figure 8

Costs of noise annoyance surveys are affected by the number of interviews and the number of survey locations. A previous analysis of noise surveys' findings reported that there is some homogeneity of reactions within survey areas which cannot be explained by noise level.<sup>22</sup> This homogeneity is commonly expressed as the intraclass correlation coefficient, the average correlation between members within survey areas. In an analysis of 24 annoyance variables from 10 surveys ( $N \approx 16,000$  respondents) the median value of the intraclass correlation was found to be  $\rho = 0.10$ . Sampling theory and standard survey sampling practice requires that this clustering of reactions be accounted for in estimating the precision of sample designs.

Table 3 presents estimates of 95% confidence intervals for the proportion annoyed at low noise levels if from 500 to 10,000 interviews were drawn from as few as 10 or as many as 100 areas. The confidence intervals assume that 7% of the population is annoyed and that  $\rho = 0.10$ . These estimated confidence intervals show that a high degree of precision can only be reached with large numbers of survey areas. For example a sample from 10 areas with 10,000 interviews is less accurate than a sample from 20 areas with only 500 interviews. The importance of including a large number of areas is clear, but the confidence intervals which could be expected from different sample designs are only approximate. Quite reasonable alternative assumptions would suggest that a desirable 95% confidence interval of  $\pm 2.5\%$  which is assumed in Table 3 to be achieved with 2,000 interviews in 50 areas might in fact require 2,000 interviews in 75 areas or, on the other hand, only require less than 1000 interviews in 50 areas.

Number of interviews	Number of study areas				
	10	20	30	50	100
500	$\pm 5.4$	$\pm 4.1$	$\pm 3.6$	$\pm 3.1$	$\pm 2.6$
1,000	$\pm 5.2$	$\pm 3.8$	$\pm 3.3$	$\pm 2.7$	$\pm 2.2$
2,000	$\pm 5.1$	$\pm 3.7$	$\pm 3.1$	$\pm 2.5$	$\pm 1.9$
10,000	$\pm 5.0$	$\pm 3.6$	$\pm 3.0$	$\pm 2.3$	$\pm 1.7$

Table 3: Estimates of 95% confidence intervals for varying numbers of interviews and study areas (7% annoyed)

What contributions might further secondary analyses or new social surveys make toward estimating en route noise reactions?

Secondary analyses of previously collected, individual-level social survey data could provide more precise estimates of the effects of the variables specified in the hypotheses. The greatest contribution from secondary analyses might be to resolve the conflicting evidence on the changing noise level hypothesis. The surveys with evidence on changing noise levels varied greatly in size and analysis methods. New, parallel secondary analyses could provide standard evidence from the surveys and evaluate the possibility that sampling errors explain some differences.

Secondary analyses could contribute to other issues as well. A rigorous analysis of existing data could estimate the proportion of the population annoyed at low noise levels. To be methodologically sound it is necessary to abandon the previous practice of accepting reviewers' intuitive speculations about the calibration of the various annoyance questions. Combined survey estimates of annoyance levels should only include findings from annoyance scales which have been calibrated against each other within linking surveys.

Secondary analyses could provide a more precise estimate of possible small effects of employment benefits or low ambient noises. Any such effects have been dismissed in this paper because they did not meet the methodology's "importance" criterion. Secondary analyses could more closely specify attitudinal variables and annoyance (fear of crashes, perceived importance) but the analyses could not remove the fundamental doubts about the causal relation between such attitudes and annoyance. Secondary analyses could also serve to summarize the effects of single variables or the combined effects of multiple variables in a form which would be most applicable to noise policy. The effects could be expressed in decibel equivalent penalties or corrections which could be applied to airport/en route comparisons.

New social surveys could also provide useful evidence. A new survey could provide more convincing evidence about reactions at low noise levels if it could overcome doubts about the accuracy of previous surveys' noise measurement techniques which had not been specifically designed for low noise environments. Since there are very few surveys on the direct effect of non-noise nuisances, a new survey might make important contributions on this topic. However, such a survey would need to consider the correlations between noise level and non-noise nuisances and provide strong evidence that errors in long-term noise environment estimation techniques could not bias the estimates of the effects of the non-noise nuisances. New surveys in en route settings would provide the most direct estimates of en route reactions. Such surveys would be most useful for future planning if they were conducted in conjunction with laboratory or other studies which would make it possible to separate the effects of the unique noise source from the effects of the en route setting.

## Priorities for Future Research

Measure % annoyed at low noise levels

Use calibrated questions [Secondary Analysis]

New survey [NS]

Estimate size of effect of change (if any) [SA]

Obtain new data on non-noise effects [NS]

Quantify significance and size of effects [SA]



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